Is forestry really more profitable than upland farming? A historic and present day farm level economic comparison of upland sheep farming and forestry in the UK

Hardaker, Ashley

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Is forestry really more profitable than upland farming? A historic and present day farm level economic comparison of upland sheep farming and forestry in the UK.

Ashley Robert Hardaker
School of the Environment, Natural Resources and Geography, Bangor University

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ABSTRACT

There are currently 3.16 million hectares of woodland cover in the United Kingdom. At a European scale, the UK is one of the countries with the lowest woodland cover, currently extending to only 13% of the total land area of the UK, this is less than half of the European Union (EU) average of 37 per cent. A significant study carried out by Read *et al*., (2009) identified that UK wide there is a need to increase significantly levels of new planting and forest creation by more than 23,000 ha each year over the next 40 years if a substantial influence on reversing climate change is to be realised. It is clear that expansion of the total forested area in the UK necessitates the establishment of new woodland and forest cover on farmland which is either owner occupied or rented out.

The main barriers to woodland establishment on farmland cited in the literature, include cultural resistance notably a dichotomous view of farming and forestry as being competing land uses; and lack of awareness of the potential economic benefits of woodland. This study intended to provide information that will improve farmers and landowners understanding of the potential economic differences between business as usual (sheep farming) and woodland creation in the uplands of the UK. The aim of this study was to evaluate the bio-economic potentials of temperate upland clear fell forestry systems in the UK over the last 60 years and determine if afforestation of upland farms has historically produced, and will in the future produce better financial outcomes than conventional upland sheep farming. The study used a bio-economic model based on discounted cash flow analysis to compare and evaluate a conventional upland sheep grazing system against a temperate upland forestry system.

Historic investments to cease upland sheep grazing and afforest upland farms in the UK based on historic financial budgeting information available to farmers and landowners in 1956, 1976 would not have been an economically viable and profitable land use change compared to continuation of upland sheep grazing in the UK. Historic markets in 1956 and 1976 were not strong enough to render potential forestry investments profitable without a need for grant assistance. Investments to cease upland sheep grazing and afforest upland farms in the UK in 1996 would have been economically viable and profitable land use investment as timber markets alone were strong enough to render potential forestry investment profitable without a need for grant assistance. Without subsidy, investments to switch from upland sheep grazing and afforest upland farms in 2016 would not be an economically viable and profitable land use change. Current day timber markets alone are not strong enough to influence new woodland establishment.

KEYWORDS

Forestry, Afforestation, Economic Modelling, Uplands, Hill-farming

1.0 INTRODUCTION AND OBJECTIVES

The benefits of woodland cover are becoming ever clearer, there is growing evidence and consensus in academic circles that trees and woodlands play a key role in the mitigation of climate change and in ecosystem services delivery. There is a considerable body of evidence and research outlining the economic benefits of the forestry sector, the delivery of environmental and social benefits from woodlands and the contribution of woodlands to the function and resilience of urban and rural landscapes. This is a convincing basis for expanding the current woodland cover of the United Kingdom (UK). That being said, UK woodlands and the forestry industry face unparalleled challenges, notably climate change, globalisation, increasing demand and competition for natural resources, extreme land use pressures, financial constraints and the political upheaval following the recent “Brexit” vote.

1.1 United Kingdom woodland area

There are currently estimated to be 3.16 million hectares of woodland in the UK (Forestry Commission 2016). At a European scale, Wales is one of the countries with the lowest woodland cover, currently extending to only 13% of the total land area of the UK, this is less than half of the European Union (EU) average of 37 per cent (Forestry Commission, 2016). The overall UK forest cover of 13% of the total land area comprises 10% in England, 15% in Wales, 18% in Scotland and 8% in Northern Ireland (Forestry Commission, 2016). Figure 1 shows the total woodland area by constituent country from 1998 to 2016, the graph shows that the overall UK woodland area has increased by approximately 240,000 hectares between 1998 and 2016, this equates to an 8% increase over the 18-year period (Forestry Commission, 2016).

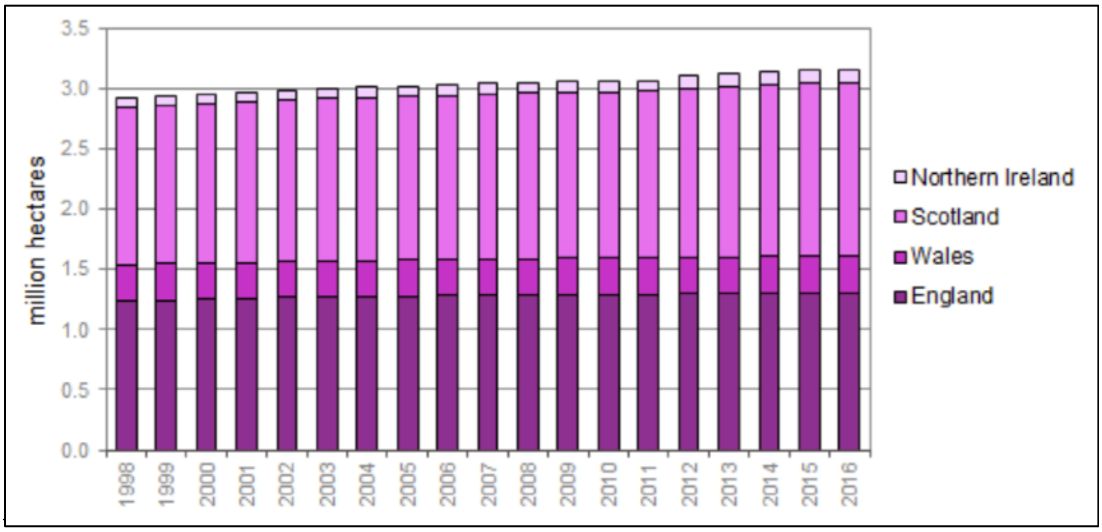

***Figure 1**: Area of UK woodland 1998 to 2016 (Forestry Commission, 2016)*

Figure 2 shows the area of new planting by each constituent UK country since 1976, it is clear that the rates of new planting in the UK have fallen since the late 1980’s. The new planting rates have decreased by approximately 82% from 1988 and 2010, this decline has been attributed by some observers to changes to the tax benefits of forest ownership in the UK brought in by the Finance Act 1988 (Forestry Commission, 2016). There was a reported increase in the area of new planting in the UK between 2010 and 2015 that was approximately twice the level of new planting reported in 2009 to 2010. The Forestry Commission (2016) new planting statistics note that this increase was driven by the introduction of Rural Development Contracts in Scotland.

It is clear that new planting has decreased in 2015 to 2016 to levels similar to those reported in 2009 to 2010. The recent decrease in levels of new planting has been attributed by some observers to lower than expected levels of uptake of grant assistance (Ellis and Frost, 2002; Church and Ravenscroft, 2008; Cunningham, 2009; Wavehill Consulting, 2009; Urquhart et al., 2010; Dandy, 2012). This has led to concern that government woodland expansion targets might not be met. A study carried out by Read *et al*., (2009) identified that UK wide there is a need to increase significantly levels of new planting and forest creation by more than 23,000 ha each year over the next 40 years if a substantial influence on reversing climate change is to be realised.

It is estimated that approximately 27% (equivalent to approximately 853,000 hectares) of the total UK woodland area in 2016 is owned or managed by the Forestry Commission, Natural Resources Wales and the Forest Service (Forestry Commission, 2016). It is clear that expansion of the total forested area in the UK necessitates the establishment of new woodland and forest cover on farmland which is either owner occupied or rented out.

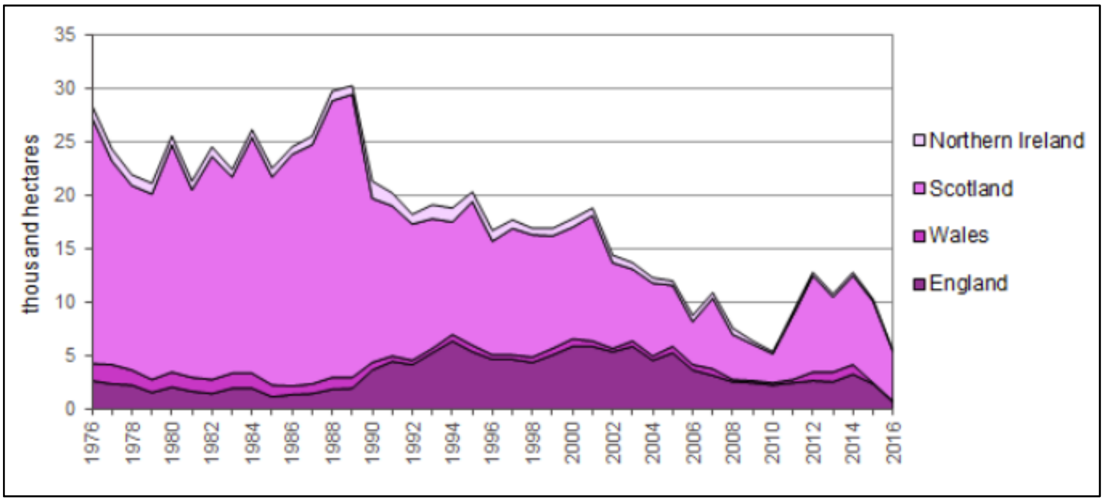

Figure 2: *Area of new woodland planting in the UK 1976 to 2016 (Forestry Commission, 2016)*

1.2 United Kingdom upland agricultural area

Although there is no statutory definition for the 'Uplands', areas above the upper limits of enclosed farmland containing dry and wet dwarf shrub heath species and rough grassland are often referred to as such (DEFRA 2010). However, in UK rural policy the upland agricultural area is synonymous with the EU Less Favoured Area (LFA) designation. The LFA designation covers all the upland and hill farming areas of the UK, therefore this paper will consider both upland and hill farming areas as “the uplands”. Land with Less Favoured Area (LFA) status accounts for around 45% of the agricultural area of the UK (Fraser, 2008). The traditional basis for farming these LFA areas is the raising of sheep and beef cattle, with the UK hills and uplands carrying around 12 million breeding ewes just over 60% of the UK total (FRASER, 2008). The uplands are areas where farming become difficult due to harsher climates, poorer soils, challenging terrain and distance from markets, which leads to lower yields and higher production and transportation costs.

1.3 Understanding landowner decision making in relation to woodland creation on farmland

In the UK forestry is a decentralised policy issue, with each constituent country having its own individual forestry policies and strategies. Expansion of the total forested area is a key forest policy issue for all of the devolved UK Governments, in some part as a reaction to climate change concerns, due to the renewable energy and carbon storage potentials (Forestry Commission, 2007; Lawrence and Dandy, 2014). In addition, some observers also note that forestry is becoming a major part of the recent move away from the prevailing productivist nature of 20th century land management as an attempt to mitigate climate change (Burton, 2004; Elands and Praestholm, 2008).

Delivering governmental forestry policy priorities is a substantial problem in the UK where a significant proportion of the land is not state owned. Gaining an understanding of the factors influencing the decisions made by private landowners (notably farmers) is key to securing the delivery of governmental forestry priorities. A regular theme underpinning the majority of the literature surrounding forest landowner engagement with forestry policy is that private landowners are not achieving governmental forest policy desires (Lawrence and Dandy, 2014).

1.3.1 The influence of economics in landowner's decision to plant and manage woodlands

There is evidence to suggest that even though landowners often consider balancing financial costs relevant in the decision making process, they do not consider income generation as a primary motivation for establishing woodland and forest cover. Some studies found that a small number of landowners noted that there is potential for generation of a small income from woodlands (Blackstock and Binggeli, 2000; Land Use Consultants, 2007). Conversely other studies found a large number of landowners hold a belief that establishment of woodlands and forests will generate little economic benefit (McMorran, 2007; Church and Ravenscroft, 2008). A study carried out in Wales found that many farmers hold the opinion that financial rewards from the establishment of woodland cover are low (Wavehill Consulting, 2009). Equally, a study carried out by Render, (2004) in the Chilterns found that 75% of landowners reported management of their woodland returned no income.

UK wide, Glynn et al., (2012) note that only 15% of landowners report their woodlands as profitable and 49% reporting their woodlands as financially neutral. Sharpe *et al*., (2001) identified mixed perceptions of poor economics in that many of the landowners were dissuaded from managing their woodlands commercially due to concerns over poor profitability. Yet 87% of the same landowners would manager their woods commercially if they were only to cover their costs. Ward and Manley, (2002) and Leach *et al*., (2012) reported other economic influences including worries over the loss of EU Single Payments (now Basic Payments), land prices, opportunity costs associated with land use change and the perceived greater profitability of agriculture.

Potentially one of the largest financial impacts of tree planting could be a change in land values. Generally the more productive the land the greater the loss in capital value when tree planting occurs. Planting new woodland on agricultural land could have a variety of impacts on the finances of the farm business. On the downside output falls livestock sales and an annual income stream. On the plus side variable and some fixed costs could be reduced. It is clear that effects on farm business finances is a significant influence on farmers decisions to move away from farming in favour of afforestation.

1.3.2 The influence of grant assistance in landowner's decision to plant and manage woodlands

There are a number of studies that identify grant assistance as an element of landowner decision making, with some evidence suggesting it is a key influence (Nicholls and Young, 2005; Silcock and Manley, 2008; Glynn *et al*., 2012). A particular study carried out by Sharpe *et al*., (2001) in East Anglia notes that 82% of woodland owners felt that financial assistance would influence them to commercially manage their woodlands, in addition 73% felt that improved markets would also influence them to commercially manage their woodlands. On the other hand, some studies suggest that grant assistance has little influence on the decisions made by woodland owners, mainly due to economic benefits of ownership being of little concern (Ward and Manley, 2002; Church and Ravenscroft, 2008; Leach *et al*., 2012).

A number of studies have found that landowners are often dissuaded from interacting with grant assistance due to perceived bureaucracy and complex administration (Ellis and Frost, 2002; Church and Ravenscroft, 2008; Cunningham, 2009; Wavehill Consulting, 2009; Urquhart et al., 2010; Dandy, 2012). What is more, a significant number report that many landowners feel the level of grant assistance is not adequate to incentivise new woodland creation (Bateman et al., 1996; Bell, 1999; Sharpe et al., 2001; Silcock and Manley, 2008; Wavehill Consulting, 2009; Urquhart et al., 2010). Some of the more recent studies also noted that landowners were often dis-incentivised from engaging with grant assistance due to policy uncertainty, from previous experience of relatively frequent policy changes, changes to grant schemes and the risk of crop establishment failure leading to grant repayment (Dandy, 2009; Wavehill Consulting, 2009; Urquhart et al., 2010).

1.3.3 The influence of landowner's attitudes in decisions to establish and manage woodlands

A recurring theme within the literature is a commonly held negative attitude to woodland and forest creation amongst UK landowners. A study in Scotland identified that only 18% of farmers surveyed in the Grampian Region had any interest in establishing new woodland (Stubbs et al., 2010). There is a body of evidence regarding the attitudes of UK farming culture, notably the widely held opinion that agricultural land is for livestock and crop production and too good for planting trees, and the majority of farmers want to farm, not grow trees (Allison, 1996; Watkins, 1996; Burton, 2004). In addition, UK legislation imposes replanting conditions on the felling of forests, so the decisions to afforest agricultural land is an irreversible decision, and not one often taken lightly (Lawrence and Dandy, 2014). Furthermore, many farmers take pride in having their land in what farming culture considers to be the correct land use for productive land, in most cases livestock and arable production (Burton, 2000; Silcock and Manley, 2008).

1.4 Overview of influencing factors on landowners decisions to establish and manage woodlands

In agricultural landscapes, there is an overruling dichotomous view of farming and forestry being competing land uses. There are a number of reasons cited in explanation of the poor engagement with woodland creation amongst private landowners, including a strong cultural resistance, concerns over loss of food production (Allison, 1996; Watkins *et al*., 1996; Bell, 1999; Burton, 2004; Silcock and Manley, 2008); and a lack of awareness and poor perception of the economic benefits of woodland creation and management (Sharpe *et al.,* 2001; Ward and Manley, 2002; Render, 2004; Church and Ravenscroft, 2008; Leach *et al.,* 2012).

There is a clear theme in relation to woodland creation on farmland that many landowners, predominantly farmers, gain a significant amount of social capital from having their land in what is considered the correct land use, which in many peoples eyes is sheep farming not forestry. Forestry is often dismissed by farmers as an economically poor land use choice compared to agriculture, therefore they unlikely to decide to turn their land over to forestry.

1.5 Objectives and scope of current investigations

This study is intended to investigate the potential economic differences between sheep farming and forestry in the uplands of the UK. Financial viability is a major consideration in farmers' adoption of any land use changes, such as afforestation of farmland (Williams, 1988), yet presently, little is known about the future and historic farm level economic benefits of conversion of upland unimproved pasture to coniferous plantations. There are a number of industry report citing the large scale benefits to the UK economy of conversion of upland farms to coniferous plantation (SAC Consulting, 2014, 2015), yet there is little evidence of whether conversion is economically beneficially at a singular farm level.

The aim of this study is to evaluate the economic value of temperate upland forestry systems in UK and determine if afforestation of the uplands has historically produced, and will in the future produce better financial outcomes than continuation of conventional upland sheep farming at farm level. More specifically, this study will conduct bio-economic modelling based on discounted cash flow analysis (DCF) to compare and evaluate a conventional upland sheep grazing system against a temperate upland clear fell forestry system.

Figure 2 shows the area of new planting by each constituent UK country since 1976, the overall downward trend in new planting rates suggests that forestry was historically a more economically viable land use choice than upland sheep farming. Recent low rates of new afforestation would suggest that forestry is now a economically poor land use choice compared to sheep farming, hence farmers are reluctant to afforest their land. Therefore this study is based on the following two hypotheses:

1. An upland clear fell forestry system was historically a more economically viable land use option than an conventional upland sheep grazing system; and

2. a conventional upland sheep grazing system is currently in 2016 a more economically viable land use option than an upland clear fell forestry system.

2.0 METHODS

2.1 Farm analysis methodology

The study compared the relative profitability of two upland land use systems using a discounted cash flow analysis model based on standard agricultural and forest industry financial budgeting data commencing at a number of historic points in time. The following land use scenarios were compared:

Scenario 1: Conventional hill sheep system – spring lambing from unimproved pasture.

Scenario 2: Upland conifer plantation system – 2500 stems/ha^{-1} planted on previously grazed unimproved pasture, assuming that agricultural operations were to be abandoned.

Each scenario was compared using discounted cash flow analysis commencing at four periods in time; 1956, 1976, 1996 and 2016 over a period dictated by an upland conifer rotation of 50 years typical of historic planting decisions, to determine if forestry would have been more economically viable than agriculture in the past and if forestry is likely be more economically viable than agriculture in the future.

The study modelled the economic viability of the two land uses systems across three notional model hill farm of three sizes, assuming that in the case of Scenario 1, agricultural operations carried on unchanged and in the case of scenario 2, agricultural operations were abandoned and the whole farm area was converted to a conifer plantation. Due to extremely changeable nature of historic agricultural subsidy and forestry grant regimes the historic comparisons were undertaken taking no account of government subsidy. The 2016 comparison was initially undertaken taking no account of agricultural subsidy and forestry grant income, however a sensitivity analysis was subsequently undertaken to assess the impacts of these additional non market incomes on the results. The comparisons were undertaken on the assumption that conversion was one way from sheep farming to afforestation.

2.2 Farm level model

2.2.1 Model outline

The bio-economic model used in this study was developed as a multi period, whole farm analysis tool to assess the relative profitability of a whole farm land use change from upland hill sheep to upland conifer plantation forestry. The platform used to develop the bio-economic model was Microsoft Excel Mac, version Office 365 and consists of eight main worksheets accommodating the comparison of two land use enterprises across three model farm sizes.

The model inputs were:

a) Comparison years and model farm sizes;

b) Enterprise specific output prices, enterprise specific variable costs and enterprise specific fixed costs;

c) Enterprise specific performance data, production yields and stocking rates;

d) Discount rate

The model outputs were;

a) Discounted cash flows for each land use scenario across each comparison period; and

b) Measures of profitability and economic worth for each land use scenario.

Although the average farm size in Wales is only 40 hectares and the average flock size in wales is only 680 ewes and lambs (UK government, 2015), this study aimed to investigate and compare the relative economic viability of hill sheep agriculture with forestry across a range of holding sizes broadly representative of a range hill farms in The UK.

This study compared agriculture and forestry across three hill farm sizes classified small, medium and large. The holding sizes were calculated using the European Size Unit (ESU). The UK government Agricultural Statistics (2015) state that 29.3 breeding ewes are required for one ESU and that small holdings are ≥8 and <40 ESU, medium holdings are ≥40 and <100 ESU and large holdings are ≥100 and <200 ESU. The model farm sizes used in this study were calculated using the following formula:

$$\text{Model farm size} = \frac{a \times b}{c}$$

Where *a* = median point in UK government size criteria, *b* = ewes required for one ESU and *c* = average hill sheep stocking rate per hectare.

The calculation of the three model farm sizes used in this study is presented in Table 1.

2.2.2 Model reference farms

Table 1: Calculation of model farm sizes based on European Size Units

Size Group	**Small**	**Medium**	**Large**
UK government size criteria (ESU)	≥8 & <40	≥40 & <100	≥100 & <200
Median point in UK government size criteria (ESU)	28	70	150
Ewes required for one ESU (head)	29.3	29.3	29.3
Flock size (head)	820	2050	4030
Average hill farm stocking rate (ewes/ha)	9	9	9
Farm Size (ha)	**90**	**230**	**470**

2.2.3 Scenario 1: Conventional hill sheep spring lambing system

Model analysis of the conventional hill sheep spring lambing system aimed to illustrate the relative economic viability of a hill sheep farming enterprise typical of The UK. This scenario modelled the profitability and economic viability of a conventional hill spring lambing system, where lambs are sold off unimproved pasture. Income within the system is derived from the annual sale of lambs, wool and cull ewes and rams.

The general assumptions included within the discounted cash flow for the conventional hill sheep grazing system are as follows.

2.2.4 Conventional hill sheep spring lambing system assumptions

a) The performance data, costs of inputs and output prices are known and remain constant throughout the 60-year projection period.

b) All costs were incurred commencing in year 1 through to year 60, whilst all revenues were realised commencing in year 2 through to year 60.
c) A flock of traditional welsh mountain sheep were introduced onto unimproved pasture at a stocking rate of 9 ewes/ha^{-1} and 1 ram to 50 ewes.
d) Lambs sold per 100 ewes put to ram varied by comparison year, 45 in 1956 and 1976, 75 in 1996 and 141 in 2016.
e) An average lamb live weight for sale of 41kg was assumed.
f) Ewe and ram replacements were assumed at a rate of 23% annually.
g) 19% of the flock is culled annually, allowing for 4% mortality.
h) Variable costs for vets and meds includes worming, vaccinations, fly treatments and feet treatments.
i) Miscellaneous costs include contract shearing, scanning, lamb ear tags, carcass disposal, straw, mineral licks, marketing levy and transport costs.
j) Forage costs are based on low input unimproved permanent pasture.
k) Fixed costs include labour (paid and unpaid), power running costs, machinery running costs, rent, finance costs, general overheads and farm maintenance.
l) It is assumed that the market remains perfect and the discount rate of 3% remains constant over the projection period.
m) All budgets and cash flows are calculated and expressed in British Pounds Sterling.

The above stated assumptions were derived from the *John Nix Farm Management Pocketbook, 8th, 26th and 46th Editions,* (Nix, 1976; Nix, 1995: Redman, 2015)

2.2.5 Data Collection – Farm financial costs and enterprise performance data

Hill sheep spring lambing financial costs, performance data and output prices were sourced and adapted from following standard industry farm management and budgeting literature for the commencing year in each discounted cash flow comparison:

a) 2016 - *John Nix Farm Management Pocketbook* 46th Edition 2016 (Redman, 2015)
b) 1996 – *John Nix Farm Management Pocketbook* 26th Edition 1996 (Nix and Hill, 1995)
c) 1976 – *John Nix Farm Management Pocketbook* 7th Edition 1977 (Nix, 1976)
d) 1956 – Due to lack of standard industry farm management and budgeting information relevant to this period in time, figures from *John Nix Farm Management Pocketbook* 7th Edition 1976 (Nix, 1976) were discounted using the prevailing Retail Price Index back to get an estimate of 1956 figures. Estimates for 1956 figures were also informed by H*ouse of Commons Briefing Paper - Agriculture: Historical Statistics* (Zayed, 2016)

Where the financial budgeting information is quoted as a range of figures in the standard industry literature, a median point figure was taken for inclusion in the bio-economic model.

It must be noted that the financial costs and revenues detailed in the enterprise budgets and cash flow are only projections and estimates and are only approximations of the circumstances of real farming businesses.

The assumptions regarding unit costs and unit revenues for the conventional hill sheep spring lambing system are summarised in Appendix A and the budget for the hill sheep spring lambing system is presented at Appendix C.

2.2.6 Scenario 2: Upland conifer plantation system

This scenario aimed to model relative economic viability of a single upland conifer rotation typical of The UK where income is derived from timber sales from thinning operations and final clear fell harvest. This scenario assumed that all agricultural operations on the farm were abandoned and the whole farm area was planted with Sitka spruce *(Picea sitchensis).* The mean yield class for Sitka spruce in the UK is 14m^3/ha/year although many sites are potentially more or less productive (Bateman and Lovett, 1998; Sing et al., 2006). Therefore it is assumed that Sitka spruce was established at 2m x 2m spacing at a stocking density of 2500 stems/ha^{-1} and the crop grew at a maximum annual increment of 14m^3/ha/year (yield class 14). Growth and yield data was derived from the Forestry Commission Yield Models for Sitka spruce, YC 14 – Intermediate thinning (Edwards and Christie, 1981).

The predicted thinning and harvest yields for the upland conifer plantation system is presented in Appendix B.

It is assumed the plantation was managed and maintained on a 50-year rotation with thinning undertaken at the marginal thinning intensity (70% of the mean maximum annual increment) on a 6-year cycle (Rollinson, 1988). Felling will be undertaken starting in year 51 with one tenth of the forest being felled each year over the following ten years with a 5 year gap between felling of adjacent areas. It is assumed all operations were carried out by contractors and all timber sales were carried out through standing sales (both thinning operations and final harvest).

It is assumed that the market remains perfect and the discount rate of 3% remains constant over the projection period. All budgets and cash flows are calculated and expressed in British Pounds Sterling.

2.2.7 Data Collection - Forestry financial costs and enterprise performance data

Upland conifer plantation forestry financial costs, performance data and output prices were sourced and adapted from following standard industry forestry management and budgeting literature for the commencing year in each discounted cash flow comparison:

a) 2016 - *John Nix Farm Management Pocketbook 46th Edition 2016* (Redman, 2015), *Forestry Commission Timber Price Indices: Data to March 2017* (Forestry Commission, 2017)
b) 1996 – *John Nix Farm Management Pocketbook 26th Edition 1996* (Nix and Hill, 1995), *Forestry Commission Timber Price Indices: Data to March 2017* (Forestry Commission, 2017)
c) 1976 – *Growing trees for profit* (Deal, 1974)
d) 1956 – *Economics of Plantations* (Hiley, 1956)

It must be noted that the financial costs and revenues detailed in the enterprise budgets and cash flow are only projections and estimates and are only approximations of the circumstances of real forestry businesses.

Where the financial budgeting information is quoted as a range of figures in the standard industry literature, a median point figure was taken for inclusion in the bio-economic model.

The assumptions regarding unit costs and unit revenues for the upland conifer plantation system are summarised in Appendix B and the budget for the upland conifer plantation system is presented at Appendix D.

2.3 Farm level model economic analysis

It is assumed that land is allocated by farmers to the land use choice with the highest net returns. Land can be allocated to either of the two land uses, farming and forestry. It is assumed that land in farming use would be converted to forestry when the expected returns when the land use is in forestry are greater than when the land is in use for farming. The method of economic analysis used to evaluate the relative economic viability of each enterprise scenario in the bio-economic model was Discounted Cash Flow (DCF) analysis.

2.3.1 Cash flow budget

Initial cash flow budgets for the two enterprise scenarios (hill farming and forestry) across each holding size (small, medium and large) were constructed commencing at each of the four periods in time (1956, 1976, 1996 and 2016) based on the revenues and costs detailed in the enterprise budgets at *Appendix 3 and 4.* In total 24 cash flow budgets were constructed. The cash flow budgets present a temporal account of when costs are incurred and when revenues are realised. The cash flow budgets provide a snapshot of future financial commitments and economic viability of each of the two enterprise scenarios at each of the four periods in time. The annual net cash flow was calculated by subtracting the total annual costs and the total annual revenues.

2.3.2 Discounted cash flow budget

To reduce the future costs and revenues included in the cash flows budgets to their present day value a standard real discount rate of 3% was adopted on the recommendations of Hepburn and Koundouri (2006) and the *HM Treasury Green* Book (HM Treasury, 2003) due to the 60-year length of the investment period. Discount factors were calculated using the adopted discount rate of 3% to reduce future costs and revenues back to the present value at the commencing year of the cash flow period. The discount factor was calculated using the following formula:

$$\text{Discount Factor} = \frac{1}{(1+r)^t}$$

Where r = discount rate and t = number of years until the cost or revenue is realised

2.3.3 Discounted cash flow analysis

Using the outputs of the discounted cash flow, two methods of assessing the worth of each enterprise were used to compare the relative economic viability respectively. The two methods used were: the net present value (NPV), and annual equivalent value (AEV) as these are a commonly used approach. The same starting point of year 1 and projection duration of 60 years were used in each comparison respectively. Due to the significant time delays between afforestation and realisation of income through felling compared to the annual incomes from sheep farming, the future net returns of both land use choices need to considered at their “present day” value using the NPV to allow for comparison. in addition due to farming incomes being annual and forestry incomes arising at the end of the rotation, the AEV is used to allow for comparison of the annual incomes of each land use choice.

2.3.4 Net present value

NPV was employed as an investment decision making tool to compare the alternative enterprise options to seek the most profitable or economically viable option. Net present value is a technique used to discount all net future income streams to their present value (Hiley, 1954 & 1956). The NPV of each enterprise choice across each holding size and each time period was calculated as the sum all the discounted cash flows throughout the life of the project using the standard discount rate of 3% using the following formula:

$$\text{Net Present Value} = \sum_{t=1}^{n} \frac{(B_t - C_t}{(1+r)^t}$$

Where, t = rotation year, B_t = revenues in each project year, C_t = costs in each project year, n = number of years until the end of the project (n ranges from 1 to 60) and r = discount rate (3%).

2.3.5 Annual Equivalent Value

The previously calculated NPV figures were used to calculate the AEV (equivalent yearly income from each enterprise option) for each enterprise option. Calculation of the AEV involved deriving the expected annual income potential of alternative enterprise options by estimating the continuous annual cash flow generated over the lifespan of the investment. The AEV of the enterprise options was calculated using the following formula:

$$\text{Annual Equivalent Value} = \frac{r\,(\text{NPV})}{1-(1+r)^{-n}}$$

Where, *NPV* = net present value, *r* = rate for investment period and *n* = number of years in investment period.

2.3.6 Sensitivity analysis

Sensitivity analyses was undertaken to test the effects of the variation in the following key variables:

a) Lamb price – the baseline lamb prices in each cash flow commencement year were increased and decreased by 10% respectively.
b) Timber prices – the baseline timber prices in each cash flow commencement year were increased and decreased by 10% respectively.
c) Discount rate – the baseline discount rate of 3% was substituted for a discount rate of 2, and 4% respectively
d) Addition of prevailing forestry grant and agricultural subsidy incomes to 2016 discounted cash flow. The estimated additional incomes accounted for in the discounted cash flows are as follows:

Agricultural Subsidy - Average UK LFA Basic Payment Scheme income of £160/hectare.

Forestry Grant Scheme - Average UK Woodland Creation Grant income for new planting with conifer of £4,000 per hectare.

3.0 RESULTS

3.1 Discounted cash flow comparison results

The estimated NPV figures for the comparison of the two scenarios are presented in table 2 and figure 3. The estimated AEV figures for the comparison of the two scenarios are presented in table 3 and 4. A detailed overview of the results is presented in Appendix 3, Section A.

Table 2: NPV/Ha comparison results

Scenario	Establishment Year	Small Farm	Medium Farm	Large Farm
Agriculture Option NPV/Ha (£)	1956	-1,419.14	-1,248.10	-1,248.10
	1976	-4,395.72	-3,307.99	-3,968.13
	1996	-8,208.31	-8,208.31	-8,208.31
	2016	-12,549.85	-10,696.97	-10,982.03
Forestry Option NPV/Ha (£)	1956	-70.645	-70.23	-69.99
	1976	-341	-239.60	-322.03
	1996	285.06	287.03	403.62
	2016	-951.79	-1,024.28	-1,023.44

Table 3: AEV/Ha comparison results

Scenario	Establishment Year	Small Farm	Medium Farm	Large Farm
Agriculture Option AEV/Ha (£)	1956	-49.59	-43.41	-43.41
	1976	-158.83	-119.53	-143.38
	1996	-296.59	-296.59	-296.59
	2016	-453.46	-386.51	-396.81
Forestry Option AEV/Ha (£)	1956	-2.55	-2.54	-2.53
	1976	-12.32	-8.66	-11.64
	1996	10.30	10.37	14.58
	2016	-34.99	-37.01	-36.98

3.1.1 1956 and 1976 Discounted cash flow comparison

At a discount rate of 3% in 1956 and 1976, both a continuation of sheep farming and an investment in forestry are economically unviable with negative NPV/Ha figures. In addition, whilst the AEV/Ha figures for both land use choices are negative, the annual losses per hectare for a forestry investment are significantly smaller than for continuation of sheep farming. For upland farmers of all the model farm sizes in the UK in 1956 and 1976, a decision to afforest their holding would have secured lower annual and overall financial losses than a decision to continue with sheep farming if farming subsidies and forestry grant incomes had not been available.

3.1.2 1996 Discounted cash flow comparison

At a discount rate of 3% in 1996 an investment in forestry was economically viable with a positive NPV/Ha figure, whereas a continuation of sheep farming remained economically unviable with a negative NPV/Ha figure. An investment in returns a positive AEV/Ha figure whereas a continuation of sheep farming continues to make significant annual losses with a negative AEV/Ha figure. The results of the 1996 discounted cash flow comparison indicate that forestry was a more economically viable land use choice than continuing with upland sheep farming. For upland farmers of all of the model farm sizes in the UK in 1996, a decision to afforest their holding would have been an economically viable and profitable land use change.

3.1.4 2016 Discounted cash flow comparison

In 2016 both a continuation of sheep farming and an investment in forestry are economically unviable with negative NPV/Ha figures at a discount rate of 3%. In addition, whilst the AEV/Ha figures for both land use choices are negative, the annual losses per hectare for a forestry investment are significantly smaller than for continuation of sheep farming. For upland farmers of all the model farm sizes in the UK in 1996, a decision to afforest their holding would have secured lower annual and overall financial losses than a decision to continue with sheep farming if farming subsidies and forestry grant incomes had not been available.

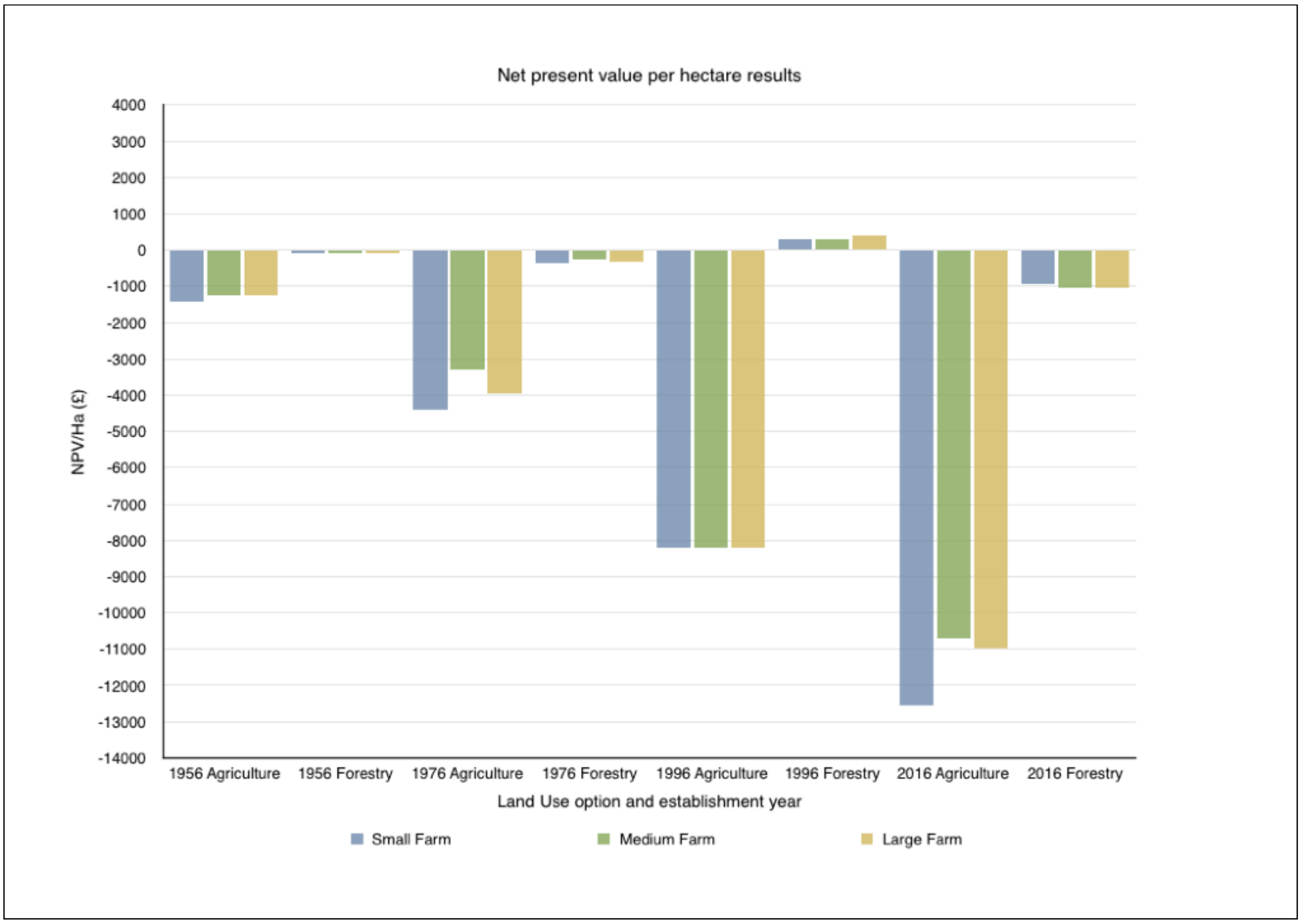

***Figure 3**: Net present value per hectare*

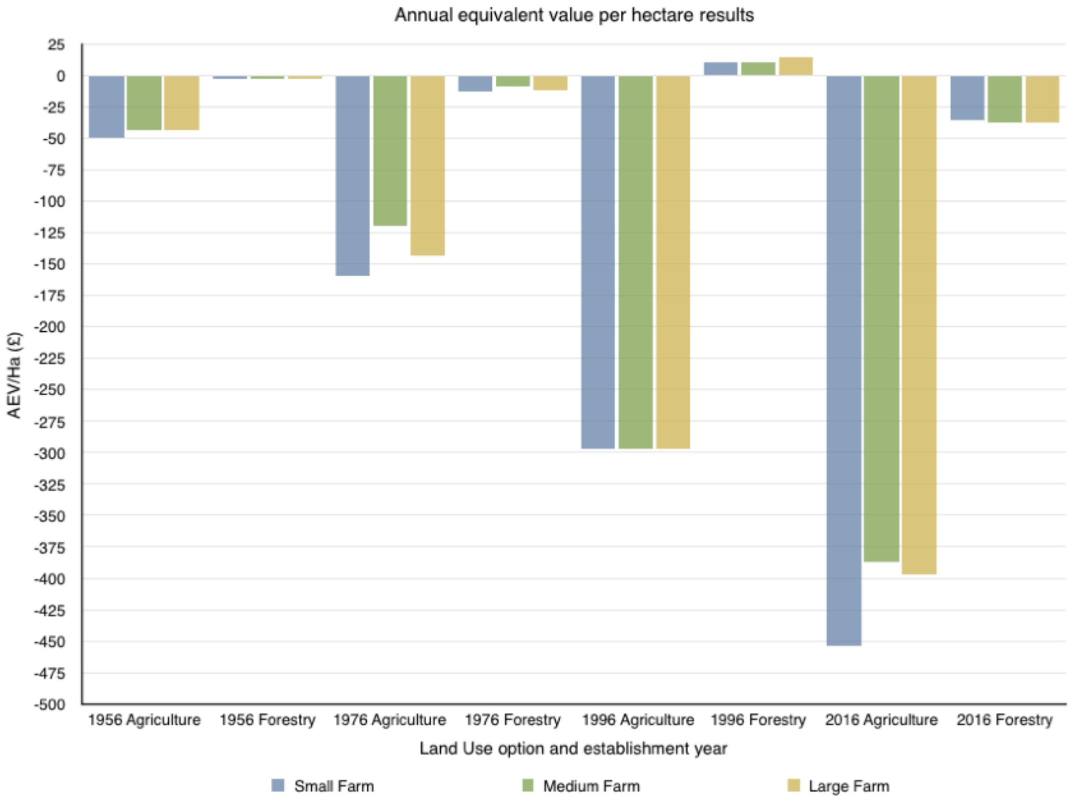

Figure 4*: Annual equivalent value per hectare*

3.2 Sensitivity analysis results – variation in timber and livestock sale prices.

The following describes the sensitivity of the results of the discounted cash flow analysis to a 10% increase and decrease in output prices at each of the discounted cash flow commencement years. The results of the effect of a 10% increase and decease in output prices on the NPV/Ha and AEV/Ha figures for each scenario are shown in Appendix 3, Section B along with a detailed overview of the results.

A 10% increase in the output prices for both timber and livestock sales does not significantly alter the relative economic viability of the investment options, and agriculture and forestry remain economically unviable land use choices in 1956 and 1976. As both land use choices returned negative NPV figures, a 10% decrease had no effect on the relative economic viability of the land use options. In 1996, a 10% increase in the output prices for both timber and livestock sales does not significantly alter the relative economic viability of the investment options, and agriculture remains an economically unviable enterprise compared to an investment in forestry which remains economically viable. In addition, a 10% decrease in output prices does not reduce the relative economic viability of an investment in forestry and it remains a more economically viable land use investment than agriculture in 1996. Much like in 1956 and 1976, a 10% increase in the output prices for both timber and livestock sales does not significantly alter the relative economic viability of the investment options, and both agriculture and forestry remain an economically unviable investment choice in 2016. A 10% decrease in the output prices for both timber and livestock sales does not alter the relative economic viability of the investment options and both enterprise choices remain economically unviable. In 2016, regardless of an increase or decrease in output prices, a choice to afforest farmland accrues smaller annual losses than a decision to continue with upland sheep grazing.

3.3 Sensitivity analysis results – variation in discount rate

The following describes the sensitivity of the results of the discounted cash flow analysis to a increase in discount rate to 4% and decrease in discount rate to 3% at each of the discounted cash flow commencement years.The results of the effect of an increase and decease in discount rate on the NPV/Ha and AEV/Ha for each scenario are shown in table 6 and 7 in Appendix 3, Section C along with a detailed overview of the results.

3.3.1 1956 Discounted cash flow comparison

A decrease in the discount rate to 2% the forestry investment option becomes economically viable with a positive NPV/Ha and AEV/Ha. At a discount rate of 2% the forestry option becomes an economically viable land use option with a significant increase in NPV/Ha and AEV/HA. Agriculture remains an economically unviable investment option at a discount rate of 2%. At an increased discount rate of 4% agriculture remains an economically unviable investment option, although as the discount rate increases, the relative economic unviability steadily decreases with an increase in NPV/Ha and AEV/Ha. At an increase in discount rate to 4% the forestry option remains an economically unviable investment option.

3.3.2 1976 Discounted cash flow comparison

A decrease in the discount rate to 2% increases the economic viability with a positive NPV and AEV/Ha of the forestry investment option in medium sized holdings only whereas the forestry option on small and large holdings remains economically unviable. Agriculture remains an economically unviable investment option at a discount rate of 2%. At an increased discount rate of 4% agriculture remains an economically unviable investment option, although as the discount rate increases, the relative economic unviability steadily decreases with an increase in NPV/Ha and AEV/Ha. In addition, an increase in discount rate to 4% renders the forestry options an economically unviable investment option, and the unviability increases as discount rate increases.

3.3.3 1996 Discounted cash flow comparison

A decrease in the discount rate to 2% increases the economic viability of the forestry investment option, compared to the baseline discount rate of 3% with an increase in the previously positive NPV and AEV/Ha. At a decreased discount rate of 2% forestry remains an economically viable land use choice. Agriculture remains an economically unviable investment option at a discount rate of 2%. At an increased discount rate of 4% agriculture remains an economically unviable investment option, although as the discount rate increases, the relative economic unviability steadily decreases. With an increase in discount rate to 4% forestry becomes an economically viable investment choice.

3.3.4 2016 Discounted cash flow comparison

Agriculture remains an economically unviable investment option at a decreased discount rate of 2%. Forestry becomes economically viable at a decreased discount rate of 2%. At an increased discount rate of 4% and 5%, agriculture remains an economically unviable investment option, although as the discount rate increases, the relative economic unviability steadily decreases with an increase in the NPV and AEV/Ha. In addition, with an increase in discount rate to 4% forestry remains an economically unviable investment choice.

3.4 Sensitivity analysis results – addition of subsidy and grant incomes

The results of the addition of agricultural subsidy and forestry grant incomes on the NPV/Ha and AEV/Ha for each scenario are shown in table 8 and 9 and figure 5 and 6.

The addition of Basic Payment Scheme incomes into the agriculture option at £160/ha has reduced the relative economic unviability (NPV/Ha of around -£5,500 to -£7,000 and AEV/HA of around -£100 to -£250) compared to a continuation of agriculture option without subsidy (NPV/Ha of around -£10,000 to -£12,000 and AEV/Ha of around -£380 to -£450). Even with the addition of subsidy income the agricultural option does remain an economically unviable land use option. The addition of Woodland creation Grant incomes into the forestry discounted cash flow at £4,000/ha has improved the relative economic viability (NPV/Ha of around £3,000 and AEV/Ha of around £110) compared to a land use investment in forestry without grant incomes (NPV/Ha of around -£380 to £450 and AEV/Ha of around -£36). With the additional income from woodland creation grants, a land use investment in forestry is a financially viable decision in 2016.

Table 8: Sensitivity of 2016 NPV/Ha to addition of agricultural subsidy and forestry grants

Scenario	Establishment year	Farm Size	No subsidy or grant income	With subsidy and grant income
Agriculture Option NPV/Ha (£)	2016	Small	-12,549.85	-7,105.79
		Medium	-10,696.97	-5,537.97
		Large	-10,982.03	-5,537.97
Forestry Option NPV/Ha (£)	2016	Small	-453.46	3,048.21
		Medium	-386.51	2,975.72
		Large	-396.81	2,976.56

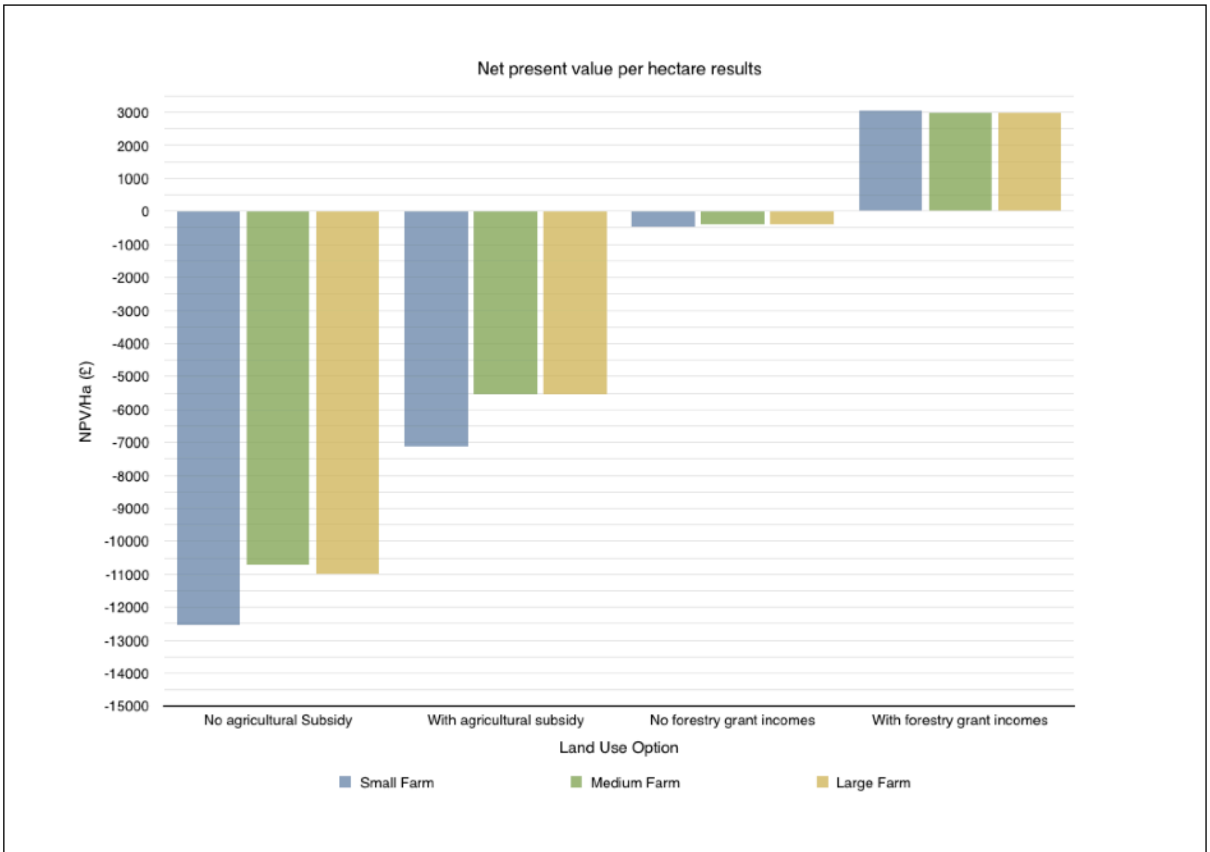

Figure 5: *Sensitivity of NPV/Ha to addition of forestry grant and agricultural subsidy income*

Table 9: Sensitivity of 2016 AEV/Ha to addition of agricultural subsidy and forestry grants

Scenario	Establishment year	Farm Size	No subsidy or grant income	With subsidy and grant income
Agriculture Option AEV/Ha (£)	2016	Small	-453.46	-256.75
		Medium	-386.51	-107.52
		Large	-396.81	-107.55
Forestry Option AEV/Ha (£)	2016	Small	-34.39	110.14
		Medium	-37.01	107.52
		Large	-36.98	107.55

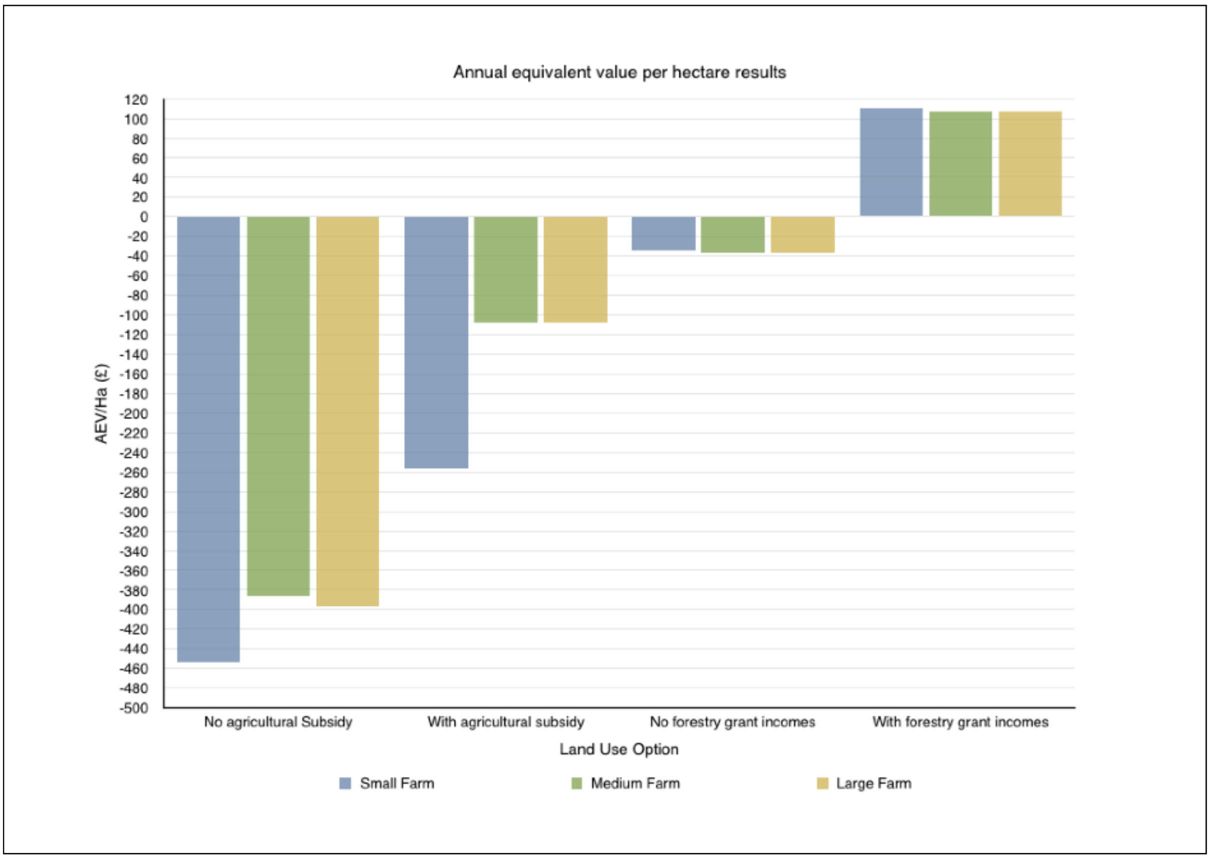

***Figure 6**: Sensitivity of AEV/Ha to addition of forestry grant and agricultural subsidy income*

4.0 DISCUSSION

This study is intended to investigate the potential economic differences between sheep farming and forestry in the uplands of the UK. This study aimed to evaluate the economic viability and potential profitability of a temperate upland clear fell forestry system in The UK compared to a business as usual continuation of upland sheep farming.Bio-economic modelling based on discounted cash flow analysis was used for the comparison and evaluation of a conventional upland sheep grazing system with a temperate upland clear fell forestry system across a range of holding sizes typical of the uplands of the UK.

4.1 Results of the present investigation

Without subsidy a historic decision to afforest upland farms on a 50 year rotation would have not have been a more economically viable land use decision compared to a continuation of upland sheep grazing based on financial budgeting information available to landowners in 1956 and 1976. This is due to the relatively low timber prices compared to the establishment costs and the length of time between expenditure on establishment and the realisation of timber incomes from thinning and clear felling. Ceasing sheep farming and move to forestry in 1996 would have been an economically viable land use decision without subsidy. This is due to the timber prices being significantly higher than the establishment costs, so even when incomes are discounted to the beginning of the investment period, the NPV and AEV figures per hectare remain positive. A decision to afforest upland farms based on budgeting information available to landowners in 2016 would not be an economically viable or profitable land use investment without subsidy, this is mainly due to a reduction in timber prices relative to an increase in establishment costs compared to previous comparison years. Even though the timber incomes are still higher than the costs, when the incomes are discounted, the NPV and AEV figures per hectare end up negative due to the establishment costs being relatively high. In all cases upland sheep grazing is economically unviable at current prices in the absence of subsidy, this is due to the input and management costs exceeding the output prices, the discounting of these losses only exacerbates the losses. Even though the forestry land use option is still economically unviable in the absence subsidy, the overall financial losses are significantly lower that those associated with continuation of sheep farming.

4.1.2 Effects of variation in the output prices on the results

An increase in output prices had a mixed influence on the economic viability of the land use investments. A 10% increase in historic timber prices decreased the financial losses associated with a forestry investment in 1956 and 1976, but it still remains an economically unviable land use decision. As expected a 10% increase in timber prices increased the economic viability of a forestry investment in 1996. In 2016, even with a 10% increase in timber prices, forestry remains economically unviable. With a 10% increase in output prices agriculture remains an economically unviable land use investment both historically and in 2016. A 10% decrease in timber prices further increased the financial losses of a forestry investment in 1956, 1976 and 2016 and it remained an economically unviable land use investment. However a 10% decrease in 1996 timber prices had little effect on the economic viability of a forestry investment and it remained and economically viable land use decision. A 10% decrease in agricultural output prices further increased the financial losses of a continuation of agriculture in 1956, 1976,1996 and 2016 and it remained an economically unviable land use investment. In 1996 the relative economic viability and profitability of a forestry investment is due to the margin between timber prices and establishment and maintenance costs being large enough that the effect of discounting was not significant enough to render the NPV negative regardless of variation in timber prices. In 1956, 1976 and 2016 the margin between the timber prices and establishment and maintenance costs is clearly not large enough to overcome the effects of discounting and the NPV was rendered negative, even though actual realised timber incomes exceed the establishment and maintenance costs. Even with an increase in output prices, the margin between agricultural output prices and input and management costs remains negative, still rendering the continuation of agriculture an economically unviable land use decision.

By altering the percentage increase timber and agricultural output prices in the discounted cash flows, it is clear that there will be a need for quite significant increases in output prices for forestry and agriculture to become economically viable land use investments in 2016. For small farms, a 26% increase in timber prices would be required to increase the NPV/Ha to £21.13 and AEV/Ha to £0.76 compared to a very large 47% increase in agricultural output prices required to increase the NPV/Ha to £165.16 and AEV/Ha to £5.97. For medium farms, a significant 29% increase in timber prices would be required to increase the NPV/Ha to £22.91 and AEV/HA to £0.83 compared to a very large 41% increase in agricultural output prices required to increase the NPV/Ha to £222.52 and AEV/Ha to £8.04. For large farms, also a large 29% increase would be required to increase the NPV/Ha to £23.74 and AEV/Ha to £0.86 compared to a very large 41% increase in agricultural output prices required to increase the NPV/Ha to £222.52 and AEV/Ha to £8.04. Recent political changes in the UK notably the decision to exit the European Union raises the question as to whether these increases in timber and agricultural output prices are realistic. The recent fall in the value of the Pound against the Euro would likely results in an increase in UK timber and agricultural output prices, it is however unlikely that significant increases of timber prices of around 26-29% and increases in agricultural output prices of around 41-47% will be realised.

4.1.3 Effects of variation in discount rate on the results

The choice of discount rate can greatly affect the profitability and economic viability of and land use investment. There is body of literature surrounding forest investment economics reporting that high discount rates can significantly reduce the NPV value of a forestry investment where the incomes are accrued late in the lifespan of the investment and often increases the NPV of land use investment where incomes are accrued earlier in the lifespan of the investment. The results of this study followed broadly the same trends. As expected, where the discount rate was reduced in the bio-economic model to 2%, historically a forest investment in across all farm sizes in 1956 and only medium farms in 1976 became economically viable where it had previously been economically unviable at 3% with a negative NPV figure. On small and large farms in 1976 an decrease in discount rate to 2% the NPV figures remain negative, meaning a forestry investment remains economically unviable. In addition, a forest investment decision in 2016 became economically viable with a positive NPV figure at a discount rate of 2%, where it was previously economically unviable at a discount rate of 3%. With an increase in discount rate to 4% a forestry investment remained economically unviable in 1956, 1976 and 2016 with a negative NPV figure and becomes economically unviable in 1996 with a now negative NPV figure. With a decrease in the discount rate to 2% the economic viability of the historic and present day continuation of agriculture decreases further with negative NPV figure. As expected, as the discount rate increased to 4%, the economic unviability of the continuation of upland sheep grazing decreased with an increase in NPV figure. As the agriculture option made significant annual losses across all farm sizes, no matter how high the discount rate would become, upland sheep grazing would not become economically viable, unless the incomes significantly exceed the costs.

It is clear that when comparing land use investments where incomes are derived on a differing time scale, (notably agriculture where incomes and are annual and forestry where incomes are realised after a gap of a number of year following expenditure) that the discount rate can have a significant effect. It can be seen from the results of this investigation that in long term investments when higher rates of interest are used the investment is likely to be less profitable. Conversely when the time between expenditure and incomes is short, as in the case of agriculture, higher investment rates increase the relative economic viability. If the discount rate is low, the investment can withstand a long period of time before realisation of returns and still often remain profitable. Williams (1988) presents a concise explanation of this relationship, he notes that the formula used to determine the compound interest factor ($1.0p^n$) can be used to explain the relative effect of discount rate and time between expenditure and incomes. In the formula, p is the rate of interest and n is the number of years of the investment. One can see that the rate of interest is raised by the power of the number of years of the investment (Williams, 1988). The number of years of the investment raises the effect of the discount factor exponentially and at the higher discount rates, the bigger the influence of the number of years is on relative profitability and economic viability of the investment (Williams, 1988).

The conclusion can be drawn that when higher discount rates are used, the period of time between expenditures and incomes must be short for the investment to remain profitable. In forestry where the investment timescale is much longer than other land use investment, it is clear that the discount rate used in the investment analysis has a significant effect on the profitability of the decision.

4.1.4 Effects of subsidy and grant incomes on results

The results of this study have shown that neither continuation of sheep farming nor a land use investment in forestry based on financial budgeting information available to landowners in 2016 would have been economically viable without subsidy. It is highly unlikely that without subsidy, farmers would be able to continue farming making annual losses of around £400/Ha. Furthermore it is also highly unlikely that farmers would look to turn their land over to forestry without grant incomes, when the huge initial investment still makes equivalent annual losses of around £35/Ha. With an addition of Woodland Creation Grant incomes at £4,000/Ha a conversion from sheep farming to forestry based on 2016 financial budgeting information would now be an economically viable land use investment, now returning the equivalent annual return of about £110/Ha. However, with the addition of Basic Payment Scheme incomes at £160/Ha a continuation of sheep farming in the uplands still makes a loss of around £100 to £250/Ha. As financial viability is a major consideration in farmers' adoption of any land use changes, such as afforestation of farmland (Williams, 1988), the cultural resistance to afforesting farmland must be strong, as even with subsidy a continuation of sheep farming in the uplands is still not economically viable. It would be fair to say that most farmers would not be able to farm at a loss for very long, hence they must be able to derive other additional incomes such as secondary employment (contracting), agri-environment schemes and other farm diversification schemes that keep upland farming profitable.

4.1.5 Results of the present investigation in relation to previous studies

There is body of literature that found many farmers felt forest establishment and management will generate little economic benefit and will not be profitable. The results of this current study support and augment these previous findings. This study has shown that a historic decisions in 1956 and 1976 to establish forests in the uplands of the UK on previously grazed land would also have not been economically viable without grant incomes and generated little economic benefit other than a reduction in the annual losses associated with sheep farming. The high levels of forestry planting during this time might have been attributed to state purchase of upland farmland by the forestry commission or a greater engagement with forestry grant schemes. An interesting finding of this study is the relative economic viability, without grant incomes, of a land use investment in forestry in 1996 compared to economic unviability of a continuation of upland sheep farming. This was due to a significant increase in timber prices compared to previous comparison years.

A decision to establish forests in the uplands of the UK in 2016 on land previously used for sheep grazing generates is not economically viable without grant incomes and generates little economic benefit other than a reduction in the annual losses associated with sheep farming. However with an addition of prevailing Woodland Creation Grant incomes conversion of grazing land to forestry would be an economically viable and profitable land use option. Despite what is often reported, many farmers are aware of rural policy priorities and the benefits and disadvantages of pursuing different management and land use options and the financial incentives attached to these. It is fair to say that many farmers take a considered view as to whether afforestation is an economically worthwhile land use change. The results of this study suggest the low levels of planting on farmland and lack of engagement with forestry grant schemes could be due to farmers giving a greater relative consideration to the loss of annual incomes, reduction in land values, loss of food production and farming livelihood in their decision making process. It is likely that the change in structure of the cashflow will have a significant effect on the decision to invest in forestry or not. The large delay between investment in tree planting and realisation of incomes through timber means that due to the ageing nature of upland farmers, many will not see the tangible financial outcomes of the large initial outlay. Unlike agriculture where there is a tangible annual income, there is no tangible annual income with forestry. However, on farms where there is no plan for succession following the retirement of the current farmer, an investment in forestry, even when it may seem financially unviable today, may bee seen as a worthwhile investment for future generations hoping that timber values will significantly increase.

There is a recurring theme within the literature that many farmers and landowners are put off from engaging with government grant assistance due to concerns surrounding the bureaucracy and complexity of administration and worries that the grant incomes are not high enough to make woodland creation economically viable. This research has found that without grant income an investment in forestry in 2016 is not profitable and markets alone are not sufficient to influence new planting of woodland in the uplands of the UK, but with an addition of grant incomes an investment in forestry is economically viable. This should raise a critical concern for UK government policy makers, there is clearly something wrong with grant scheme rules and administration if levels of grant uptake are as low as reported. There is a need for policy makers to engage with landowners to determine exactly what elements of the scheme administration or rules puts them off from engaging with them. An additional recurring theme within the literature was a feeling amongst forest owners that management of existing forests and woodlands would not generate any economic benefit, this study has shown that management of existing forests is likely to be profitable for the landowners as the costs were borne at a time when they were relatively low and timber incomes are now relatively high. There is a further need for policy makers to engage with forest owners and educate them on the favourable economic status of commercially managing established woodlands in the UK in order to meet UK Governments prior commitments to promoting economic growth in the forest sector and increasing the recognisable value of the UK forest assets.

4.1.6 Implications of the results of this study

This study has shown that without government subsidy and grant incomes a decision to establish woodland cover on upland farmland is not an economically viable land use decision. Securing the future of support payments to farmers and landowners in the UK is going to become a significant issue in the coming months as the “Brexit” comes to fruition. The decision to leave the EU does present an opportunity to redevelop financial assistance to forest owners in UK, but it is likely that the relative uncertainty over the long term future of farm support payments is going to have a major impact on the forestry sector and in particular on new planting decisions by farmers and landowners.

Considering the environmental potentials of Woodland cover, forests are relatively under monetised for their environmental benefits compared to agriculture which gains additional agri-environmental scheme income as well as direct EU subsidy. The direct payments (under Pillar 1 of the CAP) to farmers and landowners who hold land currently in agricultural production has historically accounted for the larger share of the EU CAP funding directed to the UK. Even though the proportion of the funding allocated to direct payments to farmers and landowners has been reduced in recent years through increased levels of modulation and allocation of funding to agri-environment schemes (under Pillar 2 of the Cap). The devolved UK Governments have stated on numerous occasions that there is an aspiration to reduce direct payments to farmers and landowners and for payments for environmental goods to account for a greater share of the budget. (DEFRA, 2013). There is an opportunity for the UK government to develop flexible payments for ecosystem services, carbon credits and hydrological regulation away. The future of financial support and subsidies to agriculture and forestry will depend on how much of money previously paid to the EU is directed to agriculture and forestry upon exit of the EU. It awaits to be seen what priority the UK government gives to protecting the interests of UK farmers and foresters. It is unclear what priority is given to a new rural development budget (agri-environment schemes and forestry payments are made under the rural development budget under Pillar 2 of the CAP) and if the rural development budget will indeed increase or just account for a greater percentage of a smaller overall support budget for farmers and rural landowners.

Rural development (including agriculture and forestry) is a devolved policy issue in the UK and matters regarding rural development funding post “Brexit” will be decided upon by each national government. An important element of the forthcoming debates will be whether there will be an agreement between each devolved government and central government over rural development budgets or if there will be full devolution of the future rural development decisions and budgets. It is likely that in the absence of a common administration framework (as previously existed under the EU CAP) that the divergence in the rural development schemes in each devolved nation will significantly increase. The future of rural development payments is likely to be increasingly influenced by the economic, environmental and social priorities of the devolved governments. Securing the future of grant payments for forestry is going to require significant influence from the forestry industry on national policy. Significant differences in the regional importance of the timber industry could lead to increased disparity on the national decisions regarding where to invest in woodland planting and management on farmland.

The economic desirability of a decision to afforest farmland rather is linked to prevailing agricultural land prices (Glynn, 2016). Some observers note that direct payments to farmers under the basic payment scheme in the UK increases the value of agricultural land to the detriment of woodland planting decisions (Ciaian, Kancs and Swinnen, 2014). The 2015/16 Defra Farm Business Income survey has shown that Less Favoured Area (LFA) grazing livestock businesses received on average £27,000 in subsidy payments (both BPS and agri-environment payments), contributing to an average net farm income of £19,000 (Defra, 2016). Our research along with the Defra Farm Business Income (Defra, 2016) has shown that without direct subsidy an average upland (LFA) farm in the UK would make a loss and be economically unviable. If the UK government does decide to reduce the level of direct payments to farmers and increase the level of spending on payments to landowners for environmental goods, it is conceivable that land prices may decline and increase the desirability and economic viability of afforestation on upland farmland.

In addition, other potential reactions to reductions in direct farm subsidies might see the merger of farms, ranch style extensification and in some cases land abandonment. It is probable that most farmers and landowners will continue production on the most productive areas and areas with the greatest environmental value which are likely to continue to receive payments. The abandonment of agricultural production on marginal land may increases the relative attractiveness of a land use change in favour of woodland planting even though the first rotation will be economically unviable, it will secure a supplementary income for future rotations and generations. As a devolved government issue, and with the farming and forestry sectors representing differing shares of each national economy, it is probable that the actual outcome will vary greatly, leading to future disparity in the economic viability of farming and forestry in the uplands of the UK. It is likely that there will be vast regional disparity in the relative viability of farm forestry in the uplands of the UK based on the nature of the amended system of farm payments in the individual devolved nations of the UK.

4.1.7 Limitations of the methodology

The main approach to assessing forestry investment decisions by land owners is the use of traditional DCF techniques such as NPV and AEV. The academic literature noters that DCF analysis with many advantages over other investment evaluation methodologies (such as cost benefit analysis), notably that it is less vulnerable to accounting formalities, factors in risk and the time value of money and grants the same results despite the risk preference of the investor in that the results are economically rational and quantitative (Thomas, 2001; Mun, 2006; Regan et al., 2015). Whats more, DCF analysis does support effective decision making if the investment options (agriculture or forestry) fulfil some key assumptions. The traditional DCF approach is based on the assumption that investment options are under stable environmental conditions, the uncertainty is low enough and cash flows follow a consistent pattern to make reasonably precise cash flow forecasts. Whilst a DCF approach to comparison of continuation of agriculture and investment in forestry is a robust and widely accepted approach, there is the question as to whether the relative uncertainty over future timber and agricultural output prices violates the assumptions associated with DCF analysis. Furthermore , it is difficult to decide on what is the correct discount rate to use. It is well established that the higher the uncertainty associated with the land use options, the higher the discount rate should be used to reflecting a higher risk premium (Adler, 2000). The results of this study have shown that the higher discount rate favours the agricultural option where incomes are annual, whereas the lower discount rate favours the forestry option. The higher discount rates greatly diminish later years cash flows where there is a large delay between expenditure and realisation of incomes. The DCF approach does also overlook qualitative benefits that frequently influence strategic land use investment decisions (Yeo & Qiu, 2003)

The most significant drawbacks of using a DCF approach is it is static and linear in nature, it ignores future opportunities or strategic alternatives, regards investment decisions as now or never and the flexibility to modify decision as new opportunities arise is overlooked. (Duku-Kaakyire and Nanang, 2004; Schachter & Mancarella, 2016). DCF methodology assumes that regardless of uncertainty a land use decision will be made and continuously operated until the end of its lifespan, which for forestry is the case, but for a decision to continue with agriculture based on a DCF approach overlooks the opportunity to turn land over to forestry in future years. An alternative approach to comparison of strategic land use investments is the use of Real Options Analysis (ROA). A real options approach can be described as the right but not the obligation to make the strategic investment, moreover a ROA theory accepts the landowners ability to change a strategic land use investment project with the purpose of profit maximisation and risk minimisation ((Duku-Kaakyire and Nanang, 2004). The main advantage of a ROA compared to traditional DCF techniques is that it takes into account the ability to delay an irreversible invest (such as forestry) and its effect on the land use decision (Duku-Kaakyire and Nanang, 2004). It is important to note that a ROA will not replace more traditional DCF approaches to investment decision making, an ROA approach should be applied as an additional analysis tool. ROA increases the overall understanding of effects of an investment and aids with the accounting of uncertainty that a DCF approach does not. As the objective of this study was not to understand the effects of a strategic land use investment on the landowners ability to explore other future investment the application of a traditional DCF approach applies well in this case.

5.0 CONCLUSIONS

By considering hypothetical scenarios in which farms of differing sizes opted out of upland sheep grazing into clear fell conifer forestry in either 1956, '76, '96 or 2016. The main finding of this study is that forestry is not more profitable that upland sheep farming in the absence of subsidy and grant incomes. Bio-economic modelling found that throughout 1950's to the 1970's, timber markets alone did not provide sufficient financial return for a switch to forestry compared to sheep farming, while sheep farming itself was also economically unviable without subsidy. Neither system was financially viable in terms of revenue generated through agricultural outputs alone. In contrast, timber markets in the 1990's provided sufficient financial return for new woodland establishment to be economically viable without subsidy or grant incomes compared to a continuation of upland sheep farming which remained financially unviable based on revenues from agricultural outputs alone. Timber markets alone in 2016 provided insufficient financial return for new woodland establishment to be economically viable without subsidy or grant incomes while sheep farming itself was also economically unviable without subsidy. In the current prevailing economic climate, neither system is financially viable in terms of revenue generated through timber and agricultural outputs alone.

There is a body of literature suggesting that grant assistance has little influence on landowner's decisions to establish new woodland, but improved markets could influence expansion of woodland cover through new planting. With the addition of Basic Payment Scheme incomes continuation of upland agriculture in 2016 remains economically unviable whereas with addition of Woodland Creation Grant incomes conversion to forestry in 2016 would be economically viable and profitable. This study has shown that until markets significantly improve (in excess of a 26% increase in timber prices) a decision to plant new woodland in 2016 would not be economically viable and profitable unless farmers and landowners engage with grant assistance and receive the associated incomes. We are still well away from a point where favourable economics based on markets alone are likely to influence new planting of farm woodland in the uplands of the UK. Despite what is often reported about grant assistance having little influence on decision outcomes, many farmers are aware of rural policy priorities and the benefits and disadvantages of pursuing different management and land use options and the financial incentives attached to these. It is fair to say that many farmers take a considered view as to whether afforestation is an economically worthwhile land use change and the level of grant assistance available will play an important role in the decision making process among other factors (cultural resistance to turning farmland over to forestry, change in cash flow structure, and effect on land values).

The conclusion can be drawn that addressing farmer's cultural aversion to changing land use in favour of forestry and negative attitudes to grant scheme administration will be a major hurdle in meeting governments new woodland planting commitments. There is clearly a critical need for the UK government to address landowners' concerns about the economic viability of upland forestry and reduce the red tape associated with grant incomes and improve awareness of the benefit of grant incomes in securing the economic viability of a decision to afforest farmland. Following the exit from the EU there is a good opportunity to redevelop farm subsidy payments in each of the devolved nations of the UK and ensure that the dichotomy between forestry and farming is breached. At the same time there is a need for the forestry and farming sectors to come together and explore the economic benefits of multifunctional land use and the economic viability of agroforestry systems in the UK Uplands. In particular there is a need to develop mechanisms to incentivise woodland creation on farms that provide sufficient scale for financial viability. In addition there is a need to develop financial instruments that could annualise future timber returns into regular payments for farmers, to whom incomes continuity is of higher importance than absolute capital return that might be the focus of inward investors in forestry.

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Appendix 1: Unit Costs and Revenues

Upland Agriculture unit costs and revenues

		Commencing year	1956			1976			1996			2016		
Agriculture VARIABLE unit costs	Ewe and ram replacements	£/breeding ewe	£0.22			£0.70			£2.00			£25.10		
	Concentrates	£/breeding ewe	£0.35			£1.10			£3.50			£15.00		
	Vet and med	£/breeding ewe	£0.16			£0.50			£2.80			£10.10		
	Miscellaneous	£/breeding ewe	£0.77			£2.40			£2.00			£13.70		
	Forage costs (inc bought in forage and keep)	£/breeding ewe	£0.29			£0.90			£3.40			£9.70		
Agriculture FIXED unit costs	**labour**		**Small**	**Med**	**Lar**	**Small**	**Med**	**Lar**	**Small**	**Med**	**Lar**	**Small**	**Med**	**Lar**
	Regular labour (paid)	£/hectare							£65.00	£65.00	£65.00	£15.00	£20.00	£20.00
	Regular labour (unpaid)	£/hectare	£24.00	£22.00	£22.00	£75.00	£70.00	£70.00	£95.00	£95.00	£95.00	£345.00	£230.00	£180.00
	Casual labour	£/hectare							£10.00	£10.00	£10.00	£10.00	£10.00	£15.00
	Power and machinery running costs													
	Machinery depreciation	£/hectare							£40.00	£40.00	£40.00	£65.00	£55.00	£65.00
	Machinery running costs	£/hectare	£17.00	£15.00	£15.00	£55.00	£50.00	£50.00	£45.00	£45.00	£45.00	£60.00	£55.00	£65.00
	Contract charges	£/hectare							£20.00	£20.00	£20.00	£20.00	£20.00	£20.00
	Miscellaneous													
	Farm maintenance	£/hectare										£15.00	£10.00	£15.00
	Water and electricity	£/hectare	£8.00	£6.00	£6.00	£25.00	£20.00	£20.00	£60.00	£60.00	£60.00	£40.00	£35.00	£35.00
	General overhead expenses	£/hectare										£20.00	£20.00	£20.00
	Rent and finance costs	£/hectare	£11.00	£11.00	£11.00	£35.00	£35.00	£35.00	£75.00	£75.00	£75.00	£40.00	£55.00	£60.00
Agriculture unit revenues	Lamb sales	£/head	£4.20			£13.00			£29.50			£62.00		
	Wool	£/kg	£0.30			£0.95			£1.00			£1.10		
	Cull ewes	£/head	£3.20			£12.50			£22.50			£45.00		
	Rams Sales	£head	£6.17			£22.50			£40.00			£75.00		

Upland Forestry unit costs and revenues

		Commencing year	1956			1976			1996			2016		
Forestry VARIABLE unit costs	**Establishment**													
	Site preparation													
	Ploughing	£/hectare	£25.00			£60.00			£100.00			£170.00		
	Drainage	£/hectare				£20.00			£50.00			£90.00		
	Fencing	£/m	£0.03			£0.80			£5.00			£9.00		
	Tree planting													
	Bare rooted conifer	£/1000 trees	£5.00			£9.00			£82.50			£285.00		
	Hand planting	£/1000 trees				£7.00			£145.00			£475.00		
	Tree Protection													
	Spiral and canes	£/100 trees	£0.00			£0.00			£0.00			£0.00		
	Maintenance													
	Replacing dead trees (beating up)													
	Operation	£/hectare	£10.00			£17.00			£35.00			£165.00		
	Plant supply	£/hectare				£22.00			£40.00			£120.00		
	Weeding													
	Spot weeding with herbicide	£/hectare	£14.00			£45.00			£75.00			£100.00		
	Thinning													
	Marking up first thinning	**£/m3 marked** or *£/hectare*	**£0.04**			**£0.80**			*£40.00*			**£0.75**		
	Marking up second thinning	**£/m3 marked** or *£/hectare*	**£0.04**			**£0.80**			*£40.00*			**£0.75**		
	Marking up third thinning	**£/m3 marked** or *£/hectare*	**£0.04**			**£0.80**			*£40.00*			**£0.75**		
	Marking up fourth thinning	**£/m3 marked** or *£/hectare*	**£0.04**			**£0.80**			*£40.00*			**£0.75**		
	Marking up fifth thinning	**£/m3 marked** or *£/hectare*	**£0.04**			**£0.80**			*£40.00*			**£0.75**		
	Marking up clear fell (1/10 of total area)	**£/m3 marked** or *£/hectare*	**£0.04**			**£0.80**			*£300.00*			*£300.00*		
	Other maintenance costs	£/hectare	£3.00			£20.00			£32.50			£75.00		
Forestry FIXED unit costs	**Miscellaneous**		**Small**	**Med**	**Lar**	**Small**	**Med**	**Lar**	**Small**	**Med**	**Lar**	**Small**	**Med**	**Lar**
	Maintenance	£/hectare										£0.00	£0.00	£0.00
	Water and electricity	£/hectare	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00
	General overhead expenses	£/hectare										£0.00	£0.00	£0.00
	Rent and finance costs	£/hectare	£5.50	£5.50	£5.50	£17.50	£17.50	£17.50	£37.50	£37.50	£37.50	£20.00	£27.50	£30.00
Forestry unit revenues	Thinning (standing sale)	£/m3	£0.50			£3.50			£14.00			£19.00		
	Final harvest (clear fell standing sale)	£/m3	£2.10			£6.00			£21.00			£24.00		

Appendix 2: Enterprise Budgets

Scenario 1: Budget for Upland Spring Lambing option

Year commencing	1956			1976			1996			2016		
Farm Size	Small	Medium	Large	Small	Medium	Large	Small	Medium	Large	Small	Medium	Large
Performance Data												
Farm Size (ha)	90	230	470	90	230	470	90	230	470	90	230	470
Number of ewes	810	2070	4230	810	2070	4230	810	2070	4230	810	2070	4230
Number of rams (1 to 50 ewes)	16	41	85	16	41	85	16	41	85	16	41	85
Stocking rate (ewes per hectare)	9	9	9	9	9	9	9	9	9	9	9	9
Fleece weight per ewe (kg)	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
Cull Ewes (19%)	154	393	804	154	393	804	154	393	804	154	393	804
Ram Sales (19%)	3	8	16	3	8	16	3	8	16	3	8	16
Lambs sold per 100 ewes put to ram	45	45	45	45	45	45	75	75	75	141	141	141
Number of lambs sold	365	932	1904	365	932	1904	608	1553	3173	1142	2919	5964
Enterprise budget												
Revenue												
Lamb sales	£ 1,530.90	£ 3,912.30	£ 7,994.70	£ 4,738.50	£ 12,109.50	£ 24,745.50	£ 17,921.25	£ 45,798.75	£ 93,588.75	£ 70,810.20	£ 180,959.40	£ 369,786.60
Wool	£ 413.10	£ 1,055.70	£ 2,157.30	£ 1,308.15	£ 3,343.05	£ 6,831.45	£ 1,377.00	£ 3,519.00	£ 7,191.00	£ 1,514.70	£ 3,870.90	£ 7,910.10
Cull ewes	£ 492.48	£ 1,258.56	£ 2,571.84	£ 1,923.75	£ 4,916.25	£ 10,046.25	£ 3,462.75	£ 8,849.25	£ 18,083.25	£ 6,925.50	£ 17,698.50	£ 36,166.50
Rams Sales	£ 18.99	£ 48.53	£ 99.18	£ 69.26	£ 176.99	£ 361.67	£ 123.12	£ 314.64	£ 642.96	£ 230.85	£ 589.95	£ 1,205.55
Variable costs												
Ewe and ram replacements	£ 178.20	£ 455.40	£ 930.60	£ 567.00	£ 1,449.00	£ 2,961.00	£ 1,620.00	£ 4,140.00	£ 8,460.00	£ 20,331.00	£ 51,957.00	£ 106,173.00
Concentrates	£ 283.50	£ 724.50	£ 1,480.50	£ 891.00	£ 2,277.00	£ 4,653.00	£ 2,835.00	£ 7,245.00	£ 14,805.00	£ 12,150.00	£ 31,050.00	£ 63,450.00
Vet and med	£ 129.60	£ 331.20	£ 676.80	£ 405.00	£ 1,035.00	£ 2,115.00	£ 2,268.00	£ 5,796.00	£ 11,844.00	£ 8,181.00	£ 20,907.00	£ 42,723.00
Miscellaneous	£ 623.70	£ 1,593.90	£ 3,257.10	£ 1,944.00	£ 4,968.00	£ 10,152.00	£ 1,620.00	£ 4,140.00	£ 8,460.00	£ 11,097.00	£ 28,359.00	£ 57,951.00
Forage costs (inc bought in forage and keep)	£ 234.90	£ 600.30	£ 1,226.70	£ 729.00	£ 1,863.00	£ 3,807.00	£ 2,754.00	£ 7,038.00	£ 14,382.00	£ 7,857.00	£ 20,079.00	£ 41,031.00
Fixed costs												
labour												
Regular labour (paid)							£ 5,850.00	£ 14,950.00	£ 30,550.00	£ 1,350.00	£ 4,600.00	£ 9,400.00
Regular labour (unpaid)	£ 2,160.00	£ 5,060.00	£ 10,340.00	£ 6,750.00	£ 16,100.00	£ 32,900.00	£ 8,550.00	£ 21,850.00	£ 44,650.00	£ 31,050.00	£ 52,900.00	£ 84,600.00
Casual labour							£ 900.00	£ 2,300.00	£ 4,700.00	£ 900.00	£ 2,300.00	£ 7,050.00
Power and machinery running costs												
Machinery depreciation							£ 3,600.00	£ 9,200.00	£ 18,800.00	£ 5,850.00	£ 12,650.00	£ 30,550.00
Machinery running costs	£ 1,530.00	£ 3,450.00	£ 7,050.00	£ 4,950.00	£ 11,500.00	£ 23,500.00	£ 4,050.00	£ 10,350.00	£ 21,150.00	£ 5,400.00	£ 12,650.00	£ 30,550.00
Contract charges							£ 1,800.00	£ 4,600.00	£ 9,400.00	£ 1,800.00	£ 4,600.00	£ 9,400.00
Miscellaneous												
Farm maintenance										£ 1,350.00	£ 2,300.00	£ 7,050.00
Water and electricity	£ 720.00	£ 1,380.00	£ 2,820.00	£ 2,250.00	£ 4,600.00	£ 9,400.00	£ 5,400.00	£ 13,800.00	£ 28,200.00	£ 3,600.00	£ 8,050.00	£ 16,450.00
General overhead expenses										£ 1,800.00	£ 4,600.00	£ 9,400.00
Rent and finance costs	£ 990.00	£ 2,530.00	£ 5,170.00	£ 3,150.00	£ 8,050.00	£ 16,450.00	£ 6,750.00	£ 17,250.00	£ 35,250.00	£ 3,600.00	£ 12,650.00	£ 28,200.00

Scenario 2: Budget for Upland Forestry option

Year commencing	1956			1976			1996			2016		
Farm Size	Small	Medium	Large	Small	Medium	Large	Small	Medium	Large	Small	Medium	Large
Performance Data												
Plantation size	90	230	470	90	230	470	90	230	470	90	230	470
Fenced length	3800	6100	8700	3800	6100	8700	3800	6100	8700	3800	6100	8700
Stocking rate (trees/ha)	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500
First thinning (m3/ha-1)	44	44	44	44	44	44	44	44	44	44	44	44
Second thinning (m3/ha-1)	47	47	47	47	47	47	47	47	47	47	47	47
Third thinning (m3/ha-1)	44	44	44	44	44	44	44	44	44	44	44	44
Fourth thinning (m3/ha-1)	49	49	49	49	49	49	49	49	49	49	49	49
Fifth thinning (m3/ha-1)	49	49	49	49	49	49	49	49	49	49	49	49
Final harvest (m3/ha-1)	426	426	426	426	426	426	426	426	426	426	426	426
Enterprise budget												
Revenue												
First thinning	£ 1,980.00	£ 5,060.00	£ 10,340.00	£ 13,860.00	£ 35,420.00	£ 72,380.00	£ 55,440.00	£ 141,680.00	£ 289,520.00	£ 75,240.00	£ 192,280.00	£ 392,920.00
Second thinning	£ 2,115.00	£ 5,405.00	£ 11,045.00	£ 14,805.00	£ 37,835.00	£ 77,315.00	£ 59,220.00	£ 151,340.00	£ 309,260.00	£ 80,370.00	£ 205,390.00	£ 419,710.00
Third thinning	£ 1,980.00	£ 5,060.00	£ 10,340.00	£ 13,860.00	£ 35,420.00	£ 72,380.00	£ 55,440.00	£ 141,680.00	£ 289,520.00	£ 75,240.00	£ 192,280.00	£ 392,920.00
Fourth thinning	£ 2,205.00	£ 5,635.00	£ 11,515.00	£ 15,435.00	£ 39,445.00	£ 80,605.00	£ 61,740.00	£ 157,780.00	£ 322,420.00	£ 83,790.00	£ 214,130.00	£ 437,570.00
Fifth thinning	£ 2,205.00	£ 5,635.00	£ 11,515.00	£ 15,435.00	£ 39,445.00	£ 80,605.00	£ 61,740.00	£ 157,780.00	£ 322,420.00	£ 83,790.00	£ 214,130.00	£ 437,570.00
Final harvest	£ 8,051.40	£ 20,575.80	£ 42,046.20	£ 23,004.00	£ 58,788.00	£ 120,132.00	£ 80,514.00	£ 205,758.00	£ 420,462.00	£ 92,016.00	£ 235,152.00	£ 480,528.00
Final harvest	£ 8,051.40	£ 20,575.80	£ 42,046.20	£ 23,004.00	£ 58,788.00	£ 120,132.00	£ 80,514.00	£ 205,758.00	£ 420,462.00	£ 92,016.00	£ 235,152.00	£ 480,528.00
Final harvest	£ 8,051.40	£ 20,575.80	£ 42,046.20	£ 23,004.00	£ 58,788.00	£ 120,132.00	£ 80,514.00	£ 205,758.00	£ 420,462.00	£ 92,016.00	£ 235,152.00	£ 480,528.00
Final harvest	£ 8,051.40	£ 20,575.80	£ 42,046.20	£ 23,004.00	£ 58,788.00	£ 120,132.00	£ 80,514.00	£ 205,758.00	£ 420,462.00	£ 92,016.00	£ 235,152.00	£ 480,528.00
Final harvest	£ 8,051.40	£ 20,575.80	£ 42,046.20	£ 23,004.00	£ 58,788.00	£ 120,132.00	£ 80,514.00	£ 205,758.00	£ 420,462.00	£ 92,016.00	£ 235,152.00	£ 480,528.00
Final harvest	£ 8,051.40	£ 20,575.80	£ 42,046.20	£ 23,004.00	£ 58,788.00	£ 120,132.00	£ 80,514.00	£ 205,758.00	£ 420,462.00	£ 92,016.00	£ 235,152.00	£ 480,528.00
Final harvest	£ 8,051.40	£ 20,575.80	£ 42,046.20	£ 23,004.00	£ 58,788.00	£ 120,132.00	£ 80,514.00	£ 205,758.00	£ 420,462.00	£ 92,016.00	£ 235,152.00	£ 480,528.00
Final harvest	£ 8,051.40	£ 20,575.80	£ 42,046.20	£ 23,004.00	£ 58,788.00	£ 120,132.00	£ 80,514.00	£ 205,758.00	£ 420,462.00	£ 92,016.00	£ 235,152.00	£ 480,528.00
Final harvest	£ 8,051.40	£ 20,575.80	£ 42,046.20	£ 23,004.00	£ 58,788.00	£ 120,132.00	£ 80,514.00	£ 205,758.00	£ 420,462.00	£ 92,016.00	£ 235,152.00	£ 480,528.00
Final harvest	£ 8,051.40	£ 20,575.80	£ 42,046.20	£ 23,004.00	£ 58,788.00	£ 120,132.00	£ 80,514.00	£ 205,758.00	£ 420,462.00	£ 92,016.00	£ 235,152.00	£ 480,528.00
Variable costs												
Establishment												
Site preparation												
Ploughing	£ 2,250.00	£ 5,750.00	£ 11,750.00	£ 5,400.00	£ 13,800.00	£ 28,200.00	£ 9,000.00	£ 23,000.00	£ 47,000.00	£ 15,300.00	£ 39,100.00	£ 79,900.00
Drainage				£ 1,800.00	£ 4,600.00	£ 9,400.00	£ 4,500.00	£ 11,500.00	£ 23,500.00	£ 8,100.00	£ 20,700.00	£ 42,300.00
Fencing	£ 114.00	£ 183.00	£ 261.00	£ 3,040.00	£ 4,880.00	£ 6,960.00	£ 19,000.00	£ 30,500.00	£ 43,500.00	£ 34,200.00	£ 54,900.00	£ 78,300.00
Tree planting												
Bare rooted conifer	£ 1,125.00	£ 2,875.00	£ 5,875.00	£ 2,025.00	£ 5,175.00	£ 10,575.00	£ 18,562.50	£ 47,437.50	£ 96,937.50	£ 64,125.00	£ 163,875.00	£ 334,875.00
Hand planting				£ 1,575.00	£ 4,025.00	£ 8,225.00	£ 32,625.00	£ 83,375.00	£ 170,375.00	£ 106,875.00	£ 273,125.00	£ 558,125.00
Tree Protection												
Spiral and canes	£ -	£ -	£ -	£ -	£ -	£ -	£ -	£ -	£ -	£ -	£ -	£ -
Maintenance												
Replacing dead trees (beating up)												
Operation	£ 900.00	£ 2,300.00	£ 4,700.00	£ 1,530.00	£ 3,910.00	£ 7,990.00	£ 3,150.00	£ 8,050.00	£ 16,450.00	£ 14,850.00	£ 37,950.00	£ 77,550.00
Plant supply				£ 1,980.00	£ 5,060.00	£ 10,340.00	£ 3,600.00	£ 9,200.00	£ 18,800.00	£ 10,800.00	£ 27,600.00	£ 56,400.00
Weeding												
Spot weeding with herbicide	£ 1,260.00	£ 3,220.00	£ 6,580.00	£ 4,050.00	£ 10,350.00	£ 21,150.00	£ 6,750.00	£ 17,250.00	£ 35,250.00	£ 9,000.00	£ 23,000.00	£ 47,000.00
Thinning												
Marking up first thinning	£ 158.40	£ 404.80	£ 827.20	£ 3,168.00	£ 8,096.00	£ 16,544.00	£ 3,600.00	£ 9,200.00	£ 18,800.00	£ 2,970.00	£ 7,590.00	£ 15,510.00
Marking up second thinning	£ 169.20	£ 432.40	£ 883.60	£ 3,384.00	£ 8,648.00	£ 17,672.00	£ 3,600.00	£ 9,200.00	£ 18,800.00	£ 3,172.50	£ 8,107.50	£ 16,567.50
Marking up third thinning	£ 158.40	£ 404.80	£ 827.20	£ 3,168.00	£ 8,096.00	£ 16,544.00	£ 3,600.00	£ 9,200.00	£ 18,800.00	£ 2,970.00	£ 7,590.00	£ 15,510.00
Marking up fourth thinning	£ 158.40	£ 450.80	£ 921.20	£ 3,528.00	£ 8,096.00	£ 18,424.00	£ 3,600.00	£ 9,200.00	£ 18,800.00	£ 3,307.50	£ 8,452.50	£ 17,272.50
Marking up fifth thinning	£ 176.40	£ 450.80	£ 921.20	£ 3,528.00	£ 9,016.00	£ 18,424.00	£ 3,600.00	£ 9,200.00	£ 18,800.00	£ 3,307.50	£ 8,452.50	£ 17,272.50
Marking up clear fell (1/10 of total area)	£ 153.36	£ 391.92	£ 800.88	£ 3,067.20	£ 7,838.40	£ 16,017.60	£ 2,700.00	£ 6,900.00	£ 14,100.00	£ 2,700.00	£ 6,900.00	£ 14,100.00
Other maintenance costs	£ 270.00	£ 690.00	£ 1,410.00	£ 1,800.00	£ 4,600.00	£ 9,400.00	£ 2,925.00	£ 7,475.00	£ 15,275.00	£ 6,750.00	£ 17,250.00	£ 35,250.00
Fixed costs												
Miscellaneous												
Maintenance										£ -	£ -	£ -
Water and electricity	£ -	£ -	£ -	£ -	£ -	£ -	£ -	£ -	£ -	£ -	£ -	£ -
General overhead expenses										£ -	£ -	£ -
Rent and finance costs	£ 495.00	£ 1,265.00	£ 2,585.00	£ 1,575.00	£ 4,025.00	£ 8,225.00	£ 3,375.00	£ 8,625.00	£ 17,625.00	£ 1,800.00	£ 6,325.00	£ 14,100.00